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SHIPPING (part two)

LINERS and cargo boats, bulk grain carriers and oil tankers, refrigerator ships and trawlers: all these and many more types of merchant ships are to be seen in ports all over the world today. Each ship, particularly if it is a modern one, is likely to have been built specially for the work which it has to do and very often, also, for the route on which it is to sail.

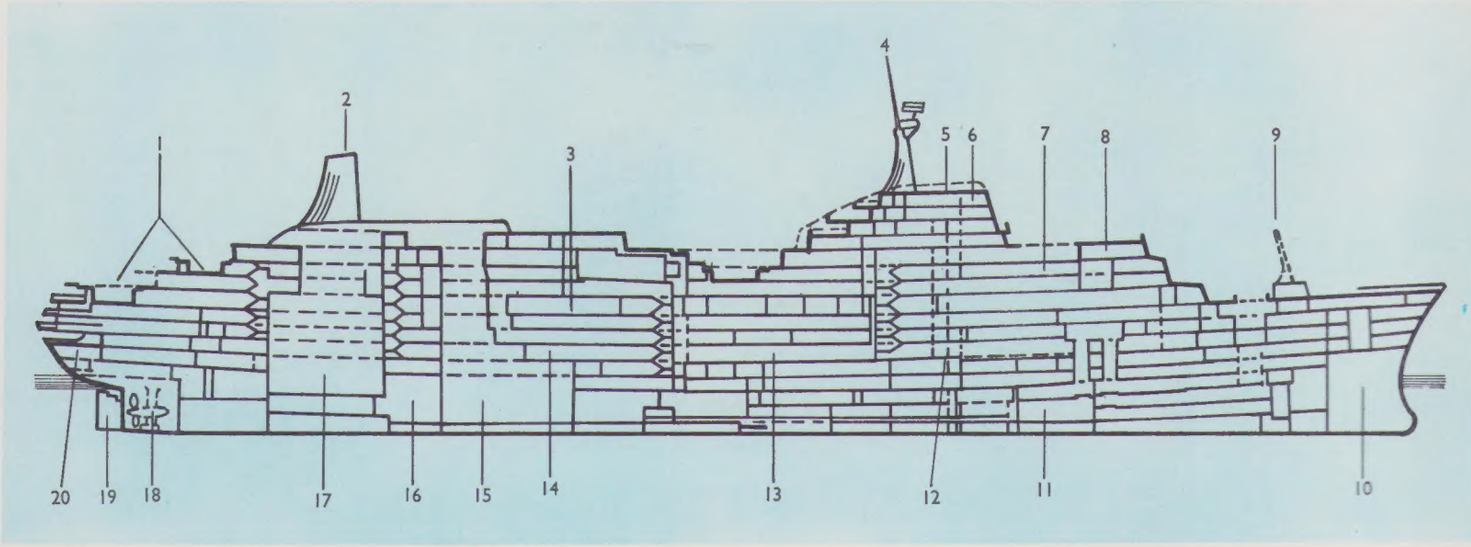
A vast liner such as the *Queen Elizabeth* is excellent for the heavy traffic between Europe and North America, but much smaller vessels are needed for the passage through the Suez Canal to India and Australia. Furthermore, where traffic is only moderately heavy and the voyage long, a number of medium-sized liners sailing at frequent intervals provide a much better service and are likely to be more fully booked than a single very large vessel sailing rather infrequently.

Although the day of the very large express passenger liner may be passing, the same cannot be said of the cargo boat. Oil tankers, in particular, continue to be made larger and larger, and two recent vessels built by the Japanese are each of 140,000 tons *deadweight*. Cargo ships, also, continue to be built larger, specially those designed to carry coal, minerals, sugar, and corn in bulk rather than in containers. There are even cargo ships built specially to carry bulk cement and methane gas.

It is not difficult to understand the reason for the increase in the size of cargo ships. A single very large ship costs less to operate than several small vessels of equivalent capacity and thus can carry goods more cheaply. Furthermore, although the air-liner may rob the ocean liner of passengers, there is no immediate prospect of any alternative means of transport being found for heavy cargo.

The Canberra

One of the most perfect examples of a modern merchant ship is the *Canberra*, built by Harland and Wolff Limited of Belfast and launched on 16th May 1960. The *Canberra* is 818·5 feet long and 102·42 feet wide; she draws 32·5 feet of water and is some 45,270 tons gross. She is the largest passenger ship built in the British Isles since the Second World War and can carry 2,238 passengers. Employed on the Southampton to Sydney run, she takes about 55 days for the voyage to Australia and back via the Suez Canal.



The Peninsular and Orientàl liner Canberra *is the type of ship which will probably capture most of the ocean-going passenger traffic in the future. She is large enough to provide the passengers with every facility but not so large that she is likely to sail with many empty berths*

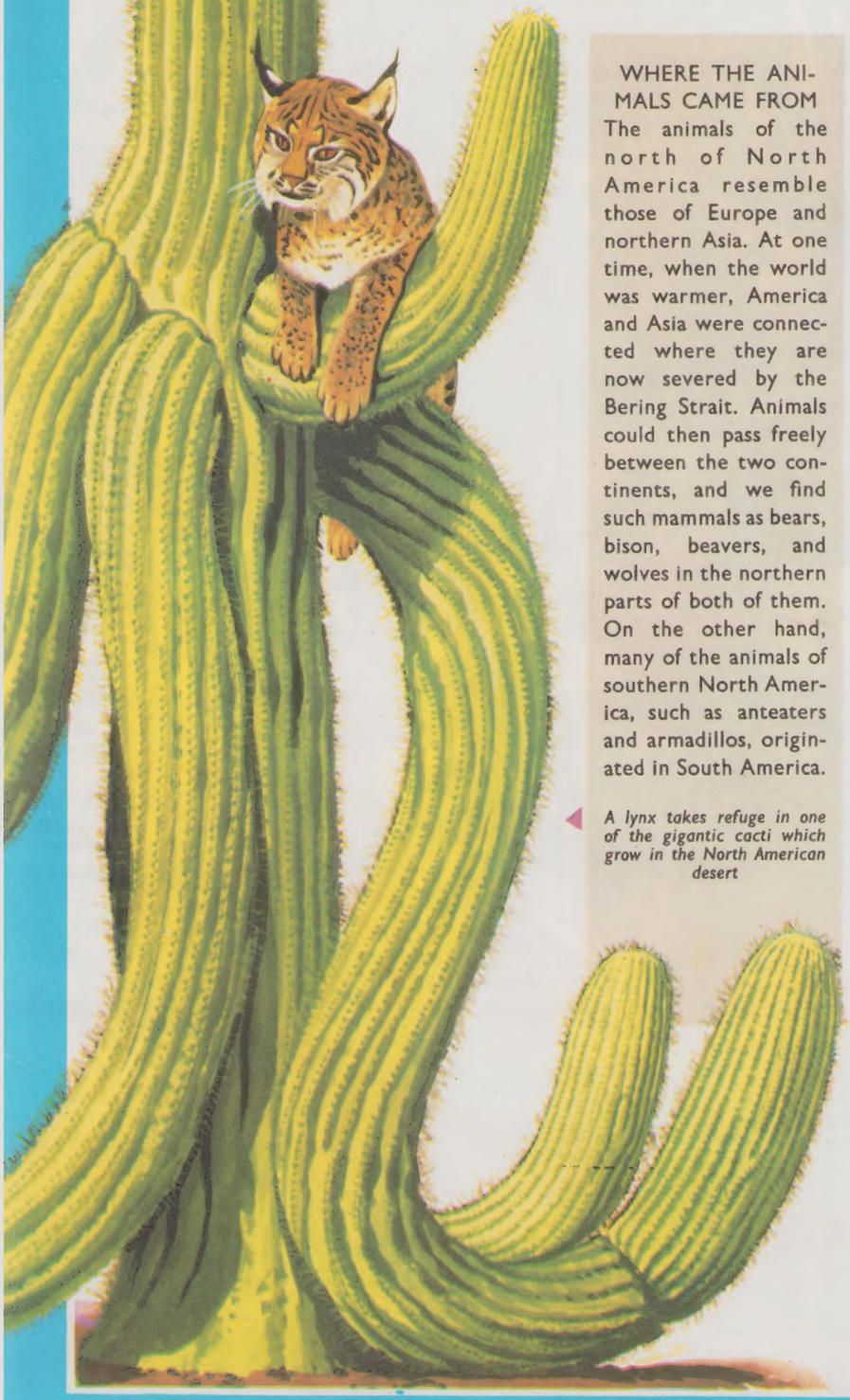
The *Canberra* has many unusual features, some of which are indicated in the sectional view shown above.
① Two swimming pools for tourist-class passengers. ② Slender twin funnels arranged side by side. ③ Accommodation for 1,690 tourist-class passengers. ④ Mast to carry radio aerials, radar scanner, and house flag. ⑤ Chart room. ⑥ Wheel house. ⑦ Accommodation for 548 first-class passengers. ⑧ Sun deck. ⑨ Derricks, one on each side of the ship, for handling cargo. ⑩ Fore peak used as a fresh-water store. ⑪ Cargo holds. ⑫ Dining-room for first-class passengers. ⑬ Galley. ⑭ Dining-room for tourist-class passengers. ⑮ Engine room containing two propulsion alternator sets. ⑯ Propulsion motor room containing 68,000-shaft-horsepower electric motors. ⑰ Boiler room to provide steam at 750 pounds per square inch pressure and 960°F for working the turbines. ⑱ Twin screws. ⑲ Rudder. ⑳ Linen room and laundry.

Previous page: the First Officer checks the loading and safe stowage of the freight on a modern cargo ship, for which he is responsible.

FAUNA AND FLORA OF NORTH AMERICA

LOOK at the map of North America. The continent stretches from inside the Arctic Circle in northern Canada and Alaska, where the ground is permanently frozen and the sea is covered with ice for a large part of the year, to the tropical regions of southern Mexico. Within this enormous range of latitude there are extremes of climate and a great variety of physical characteristics, such as high mountain ranges, deserts, low plains, and long rivers.

It is not surprising, therefore, that North America has a wide range of natural vegetation – from arctic tundra to tropical forests – and an equally wide variety of animal life – from polar bears and caribou to alligators and poisonous lizards.



A lynx takes refuge in one of the gigantic cacti which grow in the North American desert

WHERE THE ANIMALS CAME FROM

The animals of the north of North America resemble those of Europe and northern Asia. At one time, when the world was warmer, America and Asia were connected where they are now severed by the Bering Strait. Animals could then pass freely between the two continents, and we find such mammals as bears, bison, beavers, and wolves in the northern parts of both of them. On the other hand, many of the animals of southern North America, such as anteaters and armadillos, originated in South America.

Climatic regions and vegetation of North America

ANIMALS AND PLANTS IN THE DIFFERENT REGIONS

The Arctic tundra. In Alaska and northern Canada the climate is intensely cold, and the ground is permanently frozen, though the surface sometimes thaws in summer, allowing certain kinds of plants to grow. These plants – grasses, dwarf shrubs, mosses, and lichens – make up a type of vegetation known as tundra. Only a few kinds of herbivorous animals, such as the caribou (closely related to the reindeer), the musk ox, and the little rodents called lemmings, can live in these surroundings. Carnivorous animals of the tundra include wolves, Arctic foxes, and, along the coasts, polar bears. Many birds, especially ducks and geese, migrate there to breed during the brief Arctic summer, and there are seals, walruses, and whales in the surrounding seas.

The cold-temperate forest. This covers most of Canada south of the tundra and extends along the mountains of the western United States. The winters in this region are long and cold, with heavy snow, and the summers hot and moist, which favours the growth of trees, especially conifers such as pines, firs, and redwoods. Birch is mixed with the conifers

2914
caribou
moose
emperor goose
Arctic fox
snow goose
birch
timber wolf
snowy owl
king eider duck
glaucous gull
grey seal
varying hare
musk ox
harp seal
Iceland poppy
polar bear
Arctic willow
great black-backed gull
ptarmigan
puffin
bell flower
Canada goose
walrus
Greenland right whale
Stone's mountain sheep
Rocky Mountain goat
musk ox
mallard
silver fir
whooper swan
hooded seal
caribou
Canada lynx
silver firs
bison
white-headed sea eagle
black bear
coyote
black-footed ferret
raccoon
wolverine
gannet
sandhill crane
badger
grey squirrel
spruce grouse
mackerel
otter
puma
beaver
prairie dog
tulip tree
red oak
prairie chicken
poplar
hickory
cod
opossum
heloderma

Alaskan bear

in the north and oak, maple, and poplar in the south. The fauna of these northern forests includes moose (the largest of all deer), black bears, porcupines, timber wolves, Canada lynxes, wolverines, and other fur-bearing animals.

The temperate forest and cultivated region. The eastern half of the United States was once covered with forests composed of broad-leaved trees, such as hickory, black walnut, and poplar, and inhabited by bears, wolves, deer, and many other animals. Now most of the forest has gone, giving way to towns and cultivation. Some small wild animals still live there, however, among them raccoons, opossums, grey foxes, and squirrels.

The prairie. This region lies between the eastern temperate forest and the western mountains. The rainfall is too low to support natural forest, and in the west, near the mountains, sagebrush (*Artemisia*) is the characteristic plant. The central prairies are grassy, and towards the east, as the rainfall increases, the grass becomes longer. Formerly huge herds of bison roamed the prairie, but during the building of the trans-continental railways in the last century these animals were almost exterminated. The prairie chicken, a bird of the grouse family, and the remarkable pronghorn, which is neither a goat nor an antelope, though it resembles both, are typical prairie animals. Like the temperate forest, most of the prairie has now gone and is replaced by thousands of square miles of cereal crops, mainly wheat.

The desert region. In the south-western United States and Mexico the dry sagebrush of the prairie passes into desert. Here all the plants are adapted for almost waterless conditions and include cacti (sometimes 60 feet high), agave, and yucca (see page 2017). Various small rodents, the poisonous lizard (*Heloderma*), and a number of snakes are among the few animals that can live in the extreme heat and drought of the desert.

The mountain region. The great Rocky Mountains extend down western Canada and the United States and continue as the Sierra Madre in western Mexico. A number of wild animals live in this rugged mountain region, including the Rocky Mountain goat, the bighorn sheep, and the puma or cougar.

The western coniferous forest. West of the Rocky Mountains, in the western coastal region of the United States, conditions favour the growth of a variety of redwoods including the sequoia, the largest tree in the world.

The tropical region. Southern Mexico lies within the tropics, and its plants and animals are like those of South America. Palms grow in the lowland forests, and anteaters, ocelots, and several kinds of armadillo are found.

Giant redwood or sequoia trees

Fauna and flora of North America

FAUNA OF THE RIVERS AND LAKES

The fresh waters of northern North America contain salmon, trout, and other fish similar to those of Europe. The primitive gar pike (*Lepidosteus*) is an interesting southern species found in the Mississippi valley.

FREDERICK THE GREAT OF PRUSSIA

Frederick the Great of Prussia (1740–1786)

FREDERICK could hardly have been more different from his father. Whereas Frederick William, King of Prussia from 1713 to 1740, was the 'Soldier King', his son was an artist. Frederick William had the mentality of the barrack room and an infantile passion for tall soldiers. Frederick developed a taste for literature and music. He became an expert flautist and long after he became king he would find time in the most crowded day to practise the flute. He also learned Latin which his father had prohibited. He preferred the French language and customs to the German and openly despised the coarseness of German habits and life. The result was a mutual loathing between the pair. At one point the young Frederick planned to flee to England, but his plot was discovered. He was arrested, court-martialled, and deprived of his rights as Crown Prince. One of his accomplices, a close friend, was beheaded in his presence. There is reason to believe that his own life was in grave danger. Later, however, a reconciliation between father and son took place. Frederick was confirmed in his rights, and on 31st May 1740, after his father's death, he became King Frederick II of Prussia.

Frederick had already worked out a philosophy of kingship. He thought that the king governed not by Divine Right but on trust and that it was his duty to rule well. But he should rule well not in his own interests, or even those of his subjects, but in the interests of the State from which he held his trust. He had an exalted, almost mystical conception of the State, and in his own words saw the king 'as the first servant of the State'.

Frederick was intelligent enough to see that economic prosperity and the well-being of the people went hand in hand with a strong State. He, therefore, adopted an 'enlightened' domestic policy, while seeking to expand Prussia at the expense of his neighbours. In doing so he proved, despite his contempt for the Soldier King, a far greater soldier than his father and, in fact, one of the greatest of all time.

THE FIRST BLOW AGAINST AUSTRIA

Frederick had only been on the throne for five months when the Emperor Charles VI died and Maria Theresa (see page 1680) became ruler of Austria. At once he claimed for Prussia the three duchies of Silesia. Maria Theresa haughtily refused, whereupon Frederick invaded Silesia with 30,000 men.

The war of the Austrian Succession lasted eight years, though Frederick retired from the war in 1745, taking Silesia as a rich booty. Fought with varying fortunes and involving every major European country, it established Frederick's reputation as the most spectacular sovereign of his age. Thrilling victories at Mollwitz and Chotusitz showed all Europe that Prussia was now a great power and that she had a young, unscrupulous ruler ready to use the Prussian military machine to impose his will on anyone who should contest it. The war was a major victory for Prussia and a significant defeat for Austria. The acquisition of Silesia added over 1 million to the population of Prussia, which in 1740 had stood at no more than 2¼ million, or less than the population of modern Paris.

Frederick the Great (extreme left) reviews his troops. His

In the years following the war Frederick set about consolidating his gains. And in those years he firmly stamped his character on his kingdom. He reigned completely supreme, his ministers being merely vehicles to carry his will into effect. His rule, however, was progressive. Rejecting Christianity himself, he tolerated all forms of religious opinion and abolished torture for almost all crimes. He developed agriculture, constructed canals, drained marshes, and improved education. He restored the Academy of Sciences to the fame it had enjoyed before it had wilted beneath the contempt of Frederick William. Though he did not abolish serfdom, he did ease some of the worst burdens of the peasantry. He improved the quality of his army and maintained it at the colossal figure of 160,000. The Prussians were proud of the genius who was ruling them, and Frederick won the admiration and affection of his subjects.

Frederick plays the flute, an instrument on which he was an accomplished performer

Frederick's personal tastes were, as we have seen, French rather than German. He invited Voltaire to his court and indulged in long and earnest conversations with his French visitors. He wanted to become famous as an author in the French language, but none of his works, like *Mémoires pour servir l'Histoire de Brandenbourg* or the poem *L'Art de la Guerre*, were of much literary merit. Incidentally it is worth remarking that if in the 19th century a novelist Prime Minister (Disraeli) should have raised a few eyebrows, a Prussian king publishing poetry might truly seem to belong to the realm of fairy tales!

One of Frederick's after-dinner conversations with French guests

THE SEVEN YEARS WAR

While Frederick charmed Prussia, Austria, under her able minister Kaunitz, was preparing for revenge. It was Kaunitz who engineered the Diplomatic Revolution by which the traditional enmity between Austria and France was replaced by an alliance between the two. Realising that a huge coalition was about to take up arms against him, Frederick sought defence in attack and invaded Saxony. The storm broke, and Frederick found himself fighting for the very existence of his country as the armies of the Austrian Empire, Sweden, France, and Russia closed in upon him. In the months and years that followed Frederick's military skill astonished everyone. He dashed from frontier to frontier, winning a series of amazing victories. He defeated the French and Imperial troops at Rossbach and drove the Austrians out of Silesia with a victory at Leuthen. He also defeated the Russians at Zorndorf, although he suffered heavily at their hands at Hochkirsh in 1758 and the following year was routed by the combined Russian and Austrian armies at Kunersdorf. His task indeed seemed hopeless. His enemies were all larger and more populous than Prussia. His one ally, Britain, had money but no great continental army. The war developed into a series of minor but fruitless Prussian victories, with Prussian resources getting progressively smaller. Russia gave him the most trouble, and it was with his enemies closing in for the kill and himself on the verge of suicide that a near-miracle happened. In January 1762 the Tsarina of Russia, Elizabeth, died and was replaced by the pro-German Peter who admired Frederick. Russia at once withdrew her troops, defeat was averted, and the Seven Years War ended in 1763 without territorial gain or loss to Frederick, but with convincing proof that Austria was incapable of defeating her great rival in the struggle for the leadership of Germany.

unflagging zeal built up a vast and disciplined Prussian army

After the war Frederick personally supervised the country's economic recovery. He learned the lesson of diplomatic isolation and signed a long truce with Russia. In 1772 he joined with Russia and Austria in the infamous partition of Poland. This gave him Polish Prussia, which for the first time joined Brandenburg and Pomerania to East Prussia.

Though he co-operated with Austria over Poland, Frederick never lost his jealousy or fear of her. In 1777 the ruler of Bavaria died without heirs, and a war broke out with Austria in which Frederick invaded Bohemia. No pitched battle was fought in this war, and eventually a peace was signed in 1779 with minor gains for both Austria and Prussia. In 1785 Frederick formed the League of German Princes implicitly in defence against any Austrian aggression. The League dissolved after his death, but it was important as the first conscious attempt by Prussia to assume leadership of Germany against Austria.

FREDERICK'S LEGACY

When Frederick died in 1786 he left Prussia a great legacy. He had doubled her territory and trebled her population. He had made the country into a continuous block of territory. His treasury was full, containing 7 million thalers. His army consisted of 200,000 brilliantly disciplined men. His 'enlightened despotism' had set new standards for monarchs who saw the king as the servant of the State rather than the other way round. His enthusiastic work on the legal code bore fruit in the great German code of 1794. If he ignored the flowering of German culture in favour of French, he at least gave Germans the new pride which watered that very flower.

Frederick was one of the very great rulers of modern history. His achievements are often obscured by the drama of the French Revolution and the amazing career of Napoleon. But he made it certain that the future of Germany lay in Prussian, not Austrian, hands and laid the very firm foundation on which Bismarck was to build his German empire.

In the last days of the Third Reich Goebbels would read aloud to Hitler from Carlyle's *History of Frederick the Great*. When, on 13th April 1945, Goebbels heard of Roosevelt's death he immediately thought of the plight of Frederick in 1762 and exclaimed: 'The Tsarina is dead!'

THE HOME COUNTIES

Map showing the south-eastern Home Counties

The river Thames at Staines, in Middlesex

AROUND England's greatest city lie her most famous counties – counties like Surrey, Essex, and Kent, rich in history and achievement. These counties round London are the Home Counties – 'home' because they are at the very centre of England's national life. Indeed, their development has not so much mirrored England's development as preceded it. Except for rare periods in history England's progress has been firmly centred in the south-eastern corner, where the population has been generally greater, more influential, and more prosperous than in any other part of the country. Even the relative advances of the North and the Midlands during the Industrial Revolution have now been arrested, and today the 'drift to the South' has made London and the Home Counties the focus of the nation to an extent greater than ever before.

Important as they are, it is difficult to generalise accurately about the Home Counties as a region. The counties themselves – Middlesex, Surrey, Essex, Kent, Sussex, Berkshire, Buckinghamshire, and Hertfordshire – form no geographical unit. (This article deals with the first five counties. Buckinghamshire has been described on page 526; Hertfordshire on page 1614; Berkshire will be covered in a future article.) They do not, for instance, all border London; they do not share the same geological structure; they are not all traversed by the Thames; they are not all even in the south-east proper, for Essex can be considered part of East Anglia. What then do they have in common? First and foremost comes their proximity to London. They have been, and are, more directly influenced by London than any other counties. Their economies have evolved largely to supply the London market. Market gardening, concentrated in Kent and Essex, but also widespread in Berks and Bucks, is a major feature of the area. So is the mixed and dairy farming one would expect on the fringes of a large city.

The Home Counties not only supply the needs of Londoners; they also house them. Londoners are increasingly becoming divided into those who live in London and those who only work there. Every morning hundreds upon hundreds of thousands leave for London from places like Croydon, Brighton, and Gravesend, returning some time after six in the evening. This indicates another very necessary feature of the Home Counties – fast, direct access by rail to London. Indeed one almost thinks of Charing Cross as 'Kent's' railway station, Waterloo as 'Surrey's', Victoria as 'Sussex's', and so on. A corollary of this exodus and influx to and from London every day is the remarkable proportion of people engaged in business. Half Surrey's working population is made up of businessmen (or women), and the proportions are high in the rest of the Home Counties.

An unspoiled farm in the heart of rural Surrey

One result of the mobility of the Home Counties' populations is that regional characteristics have tended to die out. A man from Kent is like a man from Sussex, and both are like a man from Surrey. You *may* find an authentic rural accent in one of these counties, but this is most unlikely. The accents, when they are not 'B B C', might be called 'provincial'.

There is another service for Londoners provided by the Home Counties which must be mentioned – holidays. Sussex and Kent have done more than any other counties to establish the traditional seaside resorts. Brighton, Worthing, Eastbourne, and Bognor Regis in Sussex are matched by Folkestone, Margate, and Ramsgate in Kent. Nor is Essex, with Clacton and Southend, far behind.

The inter-relation of London and the Home Counties is apparent everywhere. Indeed those counties which border London merge into the city in those large urban sprawls beginning as London is neared. Yet for all their domination by London we must not forget that the most striking characteristic of the Home Counties is that they are 'countrified'. They are

Surrey farmland, from Leith Hill

green, beautiful, lush and healthy, which is exactly what makes them so attractive. That is why a man like Paul Getty, with his fortune of £600 million, chose to live in mid-Surrey. That is why Sir Winston Churchill chose to live at Chartwell in Kent. That is why so many prosperous executives travel up each day from Sussex, Essex, and Kent, and why a large part of Surrey is known affectionately, or enviously, as 'stockbroker country'.

One county which does not fit this pattern is Middlesex. That county is now totally absorbed by London. The process which began when 50 square miles of Middlesex were given to London County in 1888 will be completed in March 1965 when the whole county becomes officially a part of London.

It would be wrong to imagine that these characteristics are confined to the Home Counties. For example, people commute from Hampshire and Oxfordshire, and Londoners are supplied from counties, and indeed countries, far afield. But the orientation of the Home Counties towards London and London ways is somehow more complete than in others.

The structure of the Home Counties

The physical structure of the Home Counties (see page 324) is basically flat or undulating. Much of the land is dominated by the Thames. The Thames valley occupies the whole of Buckinghamshire, Hertfordshire, Essex, Berkshire, and Middlesex, as well as parts of Surrey and Kent. These parts therefore tend to be relatively low-lying (Essex is a notoriously 'flat' county) and the predominant soil is often clay.

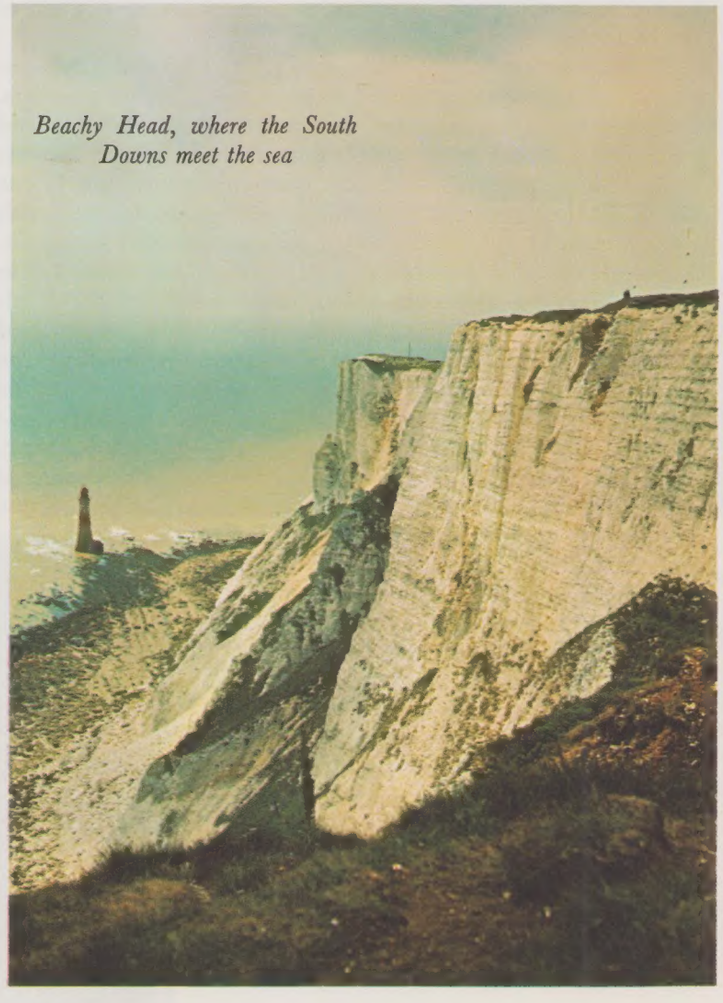
The Thames valley comes abruptly to a halt with the North Downs, a range of chalk hills which almost exactly divide Surrey in two and extend to the Kent coast. Once the chalk was much more extensive than it is now, and was linked, in fact, with the South Downs. But now the chalk in the middle has gone, leaving the Weald of Kent and Sussex in between the hills of the North and South Downs, and also leaving a magnificent view from the narrow, horseshoe-shaped promontory of the North Downs of Surrey known as the Hog's Back.

The South Downs, parallel with the south coast, terminate abruptly in the white cliffs of Beachy Head.

There are several rivers in the Home Counties. The Thames runs right through Middlesex and Hertfordshire. Rivers include the Mole and the Wey of Surrey, and the Medway, Stour, and Darent of Kent. Some of them rise in the North Downs and flow as tributaries into the Thames. There are also the rivers like the Ouse, Arun, Adur, and Cuckmere of Sussex which flow through the South Downs to the south coast.

The Home Counties 'in the front line'

We have described the character and structure of the Home Counties, but have said little about their past. Yet it is their past which not only gives added interest and excitement for



Beachy Head, where the South Downs meet the sea

Chalk downland in Sussex

County	County Town	Places of Interest
Essex (798,091 acres) Pop. 2,346,640	Chelmsford	Colchester Castle, Essex Marshes, Waltham Abbey
Kent (975,923 acres) Pop. 1,748,440	Maidstone	Canterbury and Rochester Cathedrals, Dover Castle
Middlesex (148,694 acres) Pop. 2,241,370	Brentford	Hampton Court Palace, London Airport, the great houses of Osterley and Syon
Surrey (461,833 acres) Pop. 1,756,460	Guildford	Kew Gardens, Richmond Park, Epsom racecourse
Sussex (932,559 acres) Pop. 1,105,720	Lewes (East) Chichester (West)	Arundel Castle, Brighton Pavilion, Glyndebourne

the historically-minded traveller, but is also responsible for their very appearance – their roadways, castles, cathedrals, ruins, and remains.

One of the most vital features in the history of the Home Counties, and indeed of great consequence for England, is their nearness to the Continent. It was to Kent that Julius Caesar came in 55 B C and again the following year, and he discovered that he was not the first invader with the same plan. Thousands of years earlier Bronze Age men from Belgium and Gaul had settled in south-east England. About 500 B C Celtic invaders had arrived and pushed the original inhabitants westwards towards the wildernesses of Devon, Cornwall, and Wales. When the Romans arrived they found well-organised though warring tribes in what are now the Home Counties, like the Catuvelauni in Hertfordshire, the Trinobantes in Essex, the Cantii in Kent, and the Regni in Sussex. And those first British names known to history, obscure tribal leaders like Cassivellaunus, Cunobelinus, and Caratacus, were all men of the Home Counties.

So the Romans – Julius Caesar in 55 and 54 B C and Claudius in A D 43 – followed in the wake of much earlier invaders. The Romans in turn were followed by the Angles, Saxons, and Jutes, and it is with little surprise that we learn that the earliest evidences of these invasions are concentrated in the Home Counties. They began in Kent where, perhaps in 449, the Jutish leaders Hengist and Horsa began the Anglo-Saxon Conquest. A generation later, possibly in 471, Aelle, a Saxon, landed in Sussex. Soon the whole of the south-east was under the domination of the invaders, and the Celts in their turn were pushed back to the west. The very names of the Home Counties tell the story: Sussex was the kingdom of the South Saxons; Essex of the East Saxons. Surrey – Suthri-ge, or 'southern region' – was never a separate kingdom like Essex or Sussex. It probably formed the 'southern region' of a minor kingdom which spanned both sides of the Thames. Its northern half was occupied by the Middle Saxons of Middlesex. Soon London and Middlesex came under the more powerful kingdom of Essex, and Surrey likewise fell to Kent. As the Home Counties saw the start of the Saxon Conquest, so they saw the start of the Saxon Conversion. In 597 St Augustine landed in Kent and converted its remarkable king, Ethelbert, to Christianity. Yet another major date in British history was made famous in the south-east when William the Conqueror landed in Sussex in 1066 and won the battle of Hastings at the nearby village of Battle. And in our own times a further date has been added to the illustrious list – 1940, when the Battle of Britain was fought largely over the Home Counties; when the brunt of the German bombardments was borne by the Home Counties; and when Kent became known as 'bomb alley'.

History at work

What effect has their remarkable history had upon the Home Counties? One result of the fertility, political importance, and accessibility of the Home Counties was that invading populations settled there in large numbers. For example, they became thoroughly 'Romanised'. The first Roman town of all was Colchester in Essex, and St Albans, Chichester, Rochester, Canterbury, and, of course, London, were also great Roman towns. Roman remains are found widely in the Home Counties – for example, in Middlesex, at such places as Staines, Brentford, and Stanmore; and Roman roads like Ermine Street and Watling Street cross them. In addition there are many remains of Roman villas in the countryside.

Like the Romans, the heathen Celts before them had also settled in large numbers. One of the great routes of Ancient Britain was the Pilgrims' Way passing Canterbury, Otford, Godstone Woods, Box Hill, and arriving at Dorking. In Surrey heathen place-names, like Tuesely, Wotton, Thursely, Friday Street, and Sattersley, are more numerous than in any other county.

The Saxons, of course, settled thickly and rapidly, and Saxon place-names ending in 'ing', 'ham', 'ton', and 'fold' abound. The Vikings, too, settled for a time in Essex, leaving place-names like Thorpe and Kirby. The Normans, in turn, sought the rich lands of the Home Counties, and their greatest lords divided them up. The Norman kings themselves claimed substantial portions, while the great Odo of Bayeaux became the first Earl of Kent, and William de Warenne the first Earl of Surrey. So the Home Counties continued, and were to remain, at the core of England's development. They were so important that sometimes kings like Henry II, Henry VIII, or Charles I

Historic Dover Castle, overlooking the docks

Fruit trees and oast houses, characteristic of Kent

would seek to dominate them by claiming that all of Surrey, or Essex, was 'royal forest' and therefore the property of the king. The royal parks at Richmond and Windsor are modern relics of the days when English kings claimed vast areas of the Home Counties as their own private estates.

Royalty is, of course, much in evidence in the history of the Home Counties. Many Saxon kings were buried at Kingston, and, at Richmond, Henry II, Edward III, Henry VII, and Elizabeth died. We can picture John at Dover, worried because he had just surrendered England to the Pope; Henry VIII riding on a white charger through Oxted to the Field of the Cloth of Gold; or the same king feasting at the sumptuous palace of Hampton Court which he requisitioned from Cardinal Wolsey. In fact, the Home Counties bristle with history – and with reminders like the great castle of Arundel, the home of the Duke of Norfolk, great cathedrals like Canterbury, haunted by the memories of men like Anselm, Becket, Cranmer, and Laud. Then there are the Cinque Ports – Romney, Hythe, Dover, Sandwich, and Hastings – given special privileges as the mediaeval 'front line' of defence against France.

The common folk of the Home Counties, too, have played a major part in history. Precisely because they were the most progressive and prosperous, they were the first to object to misrule. The baronial movement leading to Magna Carta was inspired by the Archbishop of Canterbury and other 'Home County' leaders with the backing of the common folk. It was signed at Runnymede, within the Surrey borders. Simon de Montfort gained much of his support from the Home Counties, and his great victory over Henry III was fought at Lewes. In later times governments feared the rebellious men of the Home Counties – particularly of Kent. Wat Tyler, who led the men of Essex and Kent in the Peasants' Revolt of 1381, was from Kent. So was Jack Cade, who rebelled against the Lancastrians in 1450, and in whose favour Kent, Sussex, and Surrey rose in support. In 1554 another man from Kent, Sir Thomas Wyatt, nearly succeeded in toppling the Tudor monarchy.

In fact, the Home Counties have witnessed the whole pageant of English history, and short of writing a complete history of England any account of the Home Counties must be incomplete. Yet, because we can talk of 'the history of the Home Counties', it must not be imagined that they have had an identical development or that they do not have any individual characteristics. The low-lying marshes of Essex contrast with the chalk hills of Sussex. The heaths of gorse and bracken in Surrey find no counterpart in lush, woody Sussex, though Surrey, too, has its woods. Kent, the 'garden of England', is unique. It has a history of progress in advance of, and strangely

Finchingsfield in Essex

dissimilar to, the rest of England. Its appearance is like the foreigner's idea of 'an England in miniature', with its orchards and hop fields arranged in small, compact units.

To describe places of interest in the Home Counties would take volumes. Historic towns like Guildford, Lewes, Canterbury, Rochester, and Colchester compete for attention with the beauty of villages like Chiddingfold and Steyning, manor houses like Cobham Hall and Chillington, beauty spots like Epping and Ashdown forests and the South Downs, sights like Surrey's 230-foot 'Long Man' carved in prehistoric times in the chalk near Lewes, or entertainments like Kew Gardens, Glyndebourne opera, or the Wimbledon tennis tournament.

The only real way to become acquainted with even a fraction of what the Home Counties have to offer is to explore them.

THE THERMOMETER

WHEN you are ill your temperature is taken with a clinical thermometer. If your mother is making sweets she will test the boiling sugar with a sugar thermometer. Thermometers are made in all sizes for use in many different places – anywhere, in fact, where people need to measure temperatures.

The first device of this kind was made by Galileo in the 15th century. His thermometer consisted of a long-necked flask filled with air and inverted over a bowl of water in such a way that the water rose a little way up the neck. In the heat of the day the level of the water fell, but when it was cool the water level rose again.

Galileo's thermometer worked because most substances expand when they are heated and contract when they are cooled. As the air in the flask warmed up it needed more space and pushed down the water in the neck. As the air cooled it needed less space and the barometric pressure (see page 452) pushed the water farther upwards. Air is so bulky that it is not a very satisfactory material with which to fill thermometers, so today most of them are filled either with mercury or with alcohol.

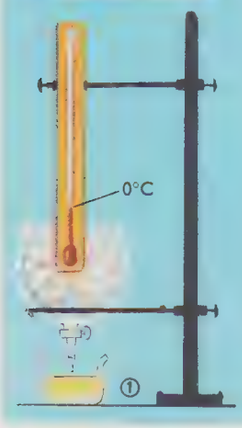
An alcohol-filled thermometer graduated in degrees Celsius

The mercury thermometer

The mercury thermometer consists of a very narrow glass tube sealed at both ends, with one end expanded into a thin-walled bulb. The bulb and part of the tube adjacent to it are filled with mercury, and the rest of the tube contains a vacuum.

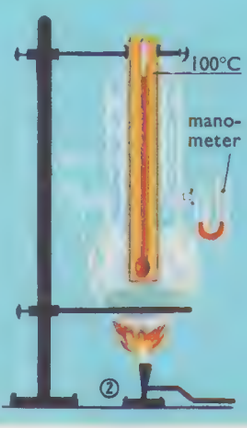
When a thermometer of this type is placed in warm surroundings heat is transferred to the mercury, and as its temperature rises the mercury expands in the only possible direction – up the narrow tube. The column of mercury in the tube thus lengthens in proportion to the increase in temperature. When the temperature falls the mercury contracts and the column shortens.

In many thermometers alcohol is used instead of mercury. As it is colourless a little red dye is always added to make it more easily visible.

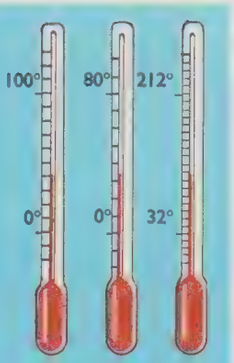


Thermometric scales

The stem of a thermometer is always marked with a series of equally spaced lines which constitute the *scale*. This enables us to use the thermometer to compare one temperature with another. This scale does not, however, help us to compare the reading on one thermometer with that on another, and so it is necessary for every thermometer to be *calibrated*.



Calibration of a thermometer consists of marking on the scale two points corresponding to two temperatures which can be reproduced easily in a laboratory. Thus one point may be obtained by placing the bulb in a bath of melting ice ① and the other by placing it in steam in equilibrium with boiling water ②. This is how thermometers are calibrated on the Celsius or Centigrade scale. The temperature of the ice bath is regarded as 0 degrees, and the temperature of the steam bath as 100 degrees. The name Centigrade implies the division of this range into 100 equal steps.



Three different thermometer scales: Celsius, Réaumur, and Fahrenheit. All are used today in Europe.

The Fahrenheit scale is calibrated in the same way. On this scale, however, the temperature of the ice bath is regarded as 32 degrees and that of boiling water as 212 degrees. On the Réaumur scale, ice is 0 degrees and boiling water 80.

The clinical thermometer

Clinical thermometers are the special types of thermometer used to measure the temperatures of the bodies of humans and animals. Since they have to be placed under the patient's tongue they are always quite small, and the glass of the bulb is very thin so that heat transfer is rapid and the correct reading is soon reached. Many thermometers on the market record a patient's temperature in half a minute.

As soon as the thermometer is removed from the patient's mouth the mercury begins to cool and contract, and in an ordinary thermometer this would cause a decrease in the reading. The clinical thermometer, however, has a small constriction just above the bulb, and as the mercury contracts the column breaks at this point leaving the mercury above the constriction. The thermometer can thus be removed from the patient's mouth without a fall in its reading. Indeed, the reading on a clinical thermometer remains unaltered until the mercury is shaken down into the bulb.

A clinical thermometer graduated on the Celsius or Centigrade scale. Normal body temperature is 37°

Conversion factors

The Celsius scale has been used for scientific work (except meteorology) throughout the world for many years. In Germany, however, the Réaumur scale is still used for some purposes, while in Britain and in North America the Fahrenheit is preferred. Various other scales are used for special purposes, the most familiar of these being the Absolute or Kelvin scale of the chemist and physicist.

It is sometimes necessary to convert a temperature measured on one scale into its corresponding value on another. With the Fahrenheit and Celsius scales this is tiresome, for not only are the steps of these two scales different but so too are their zero points.

Here is a simple way of converting Fahrenheit to Centigrade and *vice versa*:

To convert Fahrenheit to Centigrade, subtract 32 and then multiply by $\frac{5}{9}$.

To convert Centigrade to Fahrenheit, multiply by $\frac{9}{5}$ and add 32.

PARASITIC WORMS

WHEN the tide goes out at Roscoff on the coast of Brittany the beach is long and sandy, but not everywhere does it gleam a brilliant gold. From a distance it looks as if parts are covered with grass, and only a close inspection reveals that the strange colour is, in fact, due to millions of little bright-green worms, each about half an inch long and quite flat, lying on the sand.

If a few dozen of the little green worms are collected at low tide and placed in an aquarium in a laboratory a remarkable phenomenon can be seen. At the time when the tide comes in over the beach the captive worms burrow in the sand at the bottom of their tank and quite soon all are out of sight.

This strange burrowing of the little worms is merely part of their everyday behaviour. When they are on the beach they burrow each time the tide comes in and thus save themselves from being washed away. When the tide goes out they rise again to the surface and lie on the top of the sand.

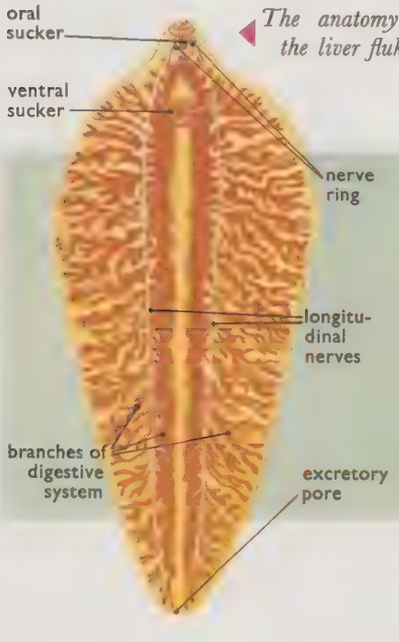
One might, of course, think that the worms would be far safer if they remained buried all the time, but unfortunately for the worms this is not possible. They live almost entirely on colonies of green algae, harbouring and protecting the algal colonies symbiotically within their bodies. Unless the worms spend part of each day on the surface, the algae inside them are unable to grow through lack of light. Consequently the worms would starve to death and the beach at Roscoff would be green no longer.

The little green worm Convoluta roscoffensis *buries itself in the sand when the tide comes in and so avoids being washed away. It continues to do this even when kept in an aquarium*

Flat worms and round worms

The little green worms that lie on the beach at Roscoff are called *Convoluta roscoffensis*, and though they are gaily coloured and interesting in their habits they are not very important. Nonetheless they are members of the great Phylum of worms known as the flat worms, or Platyhelminthes, which, together with the round worms, or Nemathelminthes, are such a terrible menace to the health of both humans and their domestic animals.

In the highly developed countries such as Britain, where standards of living and of hygiene are good, the only kind of worm infestation which is found at all commonly in humans is infestation with threadworms, and almost all children suffer from it at some time. In less advanced countries, particularly the tropical ones, worm infestations are exceedingly common. It has been estimated that of the 2,500 million people at present alive in the world no less than 2,200 million of them have at least one species of parasitic worm in their bodies.



The anatomy of the liver fluke

THE PLATYHELMINTHES

The flat worms are the lowliest of worms and have been given their name because many of them are shaped rather like a piece of tape. Nearly all of them are *hermaphrodites* – that is, the organs of both sexes are present in each worm. The Phylum is divided into three Classes.

The **Turbellaria** are the least important of the flat worms, for they are mostly free-living, parasitising neither man nor beast.

The **Cestoidea** are the tapeworms. The species which infect man vary in length from about a quarter of an inch up to 30 feet. Other species infect dogs, cats, horses, and cattle.

The **Trematoda** are very important, for this Class of platyhelminthes includes the blood flukes, or *schistosomes*, which infest more than 100 million people. This class also includes the many different species of liver fluke, one of which is a parasite of sheep and which occasionally infects human beings.

Tapeworms

Tapeworm infestations are now quite unusual in Britain, a fact which is due largely to efficient sewage disposal, good farming, and careful inspection of meat for human consumption. In countries where public health is less advanced, however, it is fairly common for humans to be infected with the pork tapeworm, *Taenia solium*, and the beef tapeworm, *Taenia saginata*.

The illustration on the right shows the cycle of the pork tapeworm. Its eggs ① are usually found on the ground near an earth closet, and from here they may find their way into a pig ② with his food. In the pig's bowel the eggs hatch into *oncospheres* which burrow through the intestinal wall and pass along the blood vessels ③ to reach muscles in various parts of the pig's body ④. In the pig's muscles the oncospheres form cysts called *cysticerci* which can be easily seen with the naked eye when the pig is killed. Meat which is infected in this way is spoken of as measly pork, and if it is not very well cooked the cysticerci survive the heating and are swallowed alive by humans ⑤. In the human host's intestine a cysticercus hatches out and grows into a tapeworm ⑥ up to 10 feet long. When the worm matures its segments, or *proglottides*, fill with eggs, break off, and are discharged with the faeces. If there is no proper method of sewage disposal a second pig may become infected and the cycle be repeated.

The pork tapeworm

The beef tapeworm is much like the pork tapeworm in appearance and life cycle except that it infects cattle rather than pigs. It is not unknown in Britain, and it is possible for people to become infected through eating rare steak in which the cysticerci have not been heated enough to kill them.

Two other tapeworms are worthy of mention, if only on account of their great difference in size. *Hymenolepis nana* is also called the dwarf tapeworm, as it seldom grows more than an inch long. It is quite common in children and is interesting in that, unlike the pork and the beef tapeworms, it does not need an intermediate host such as a pig or cow. Quite large numbers of this worm may be found in the intestine of a single human host.

The life cycle of the pork tapeworm

The largest of the tapeworms known to infest humans is called *Diphyllobothrium latum*. It has a

THE NEMATHELMINTHES

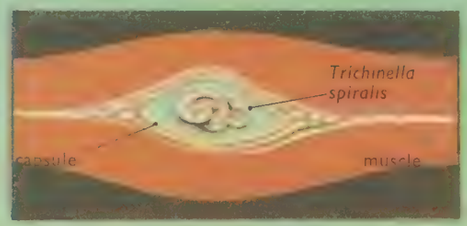
There are probably 500,000 different species of nematode worm in the world, and most of these are free-living (non-parasitic) forms found in both fresh and salt water. Some species are very small and cannot be seen at all without the aid of a microscope.

Parasitic species of nematode are known to infest nearly all vertebrate animals, many invertebrate animals, and even many plants. About a dozen species of nematode are found as parasites in humans.

Most of the nematodes are cylindrical in shape, though some species taper off at both ends and have pointed extremities. They are biologically more advanced than the platyhelminthes and are differentiated into males and females.

The trichina worm

The minute trichina worm, *Trichinella spiralis*, is only about one-eighth of an inch long. It infects many species of invertebrate animal, and during a brief lifetime in her host's intestine the female lays about 1,500 larvae. These larvae burrow through the intestinal wall and are carried in lymphatic and blood vessels to muscles in every part of the host's body. Here they turn into cysts to await the day when their host is killed and eaten. They then escape from their cysts and develop into new worms.



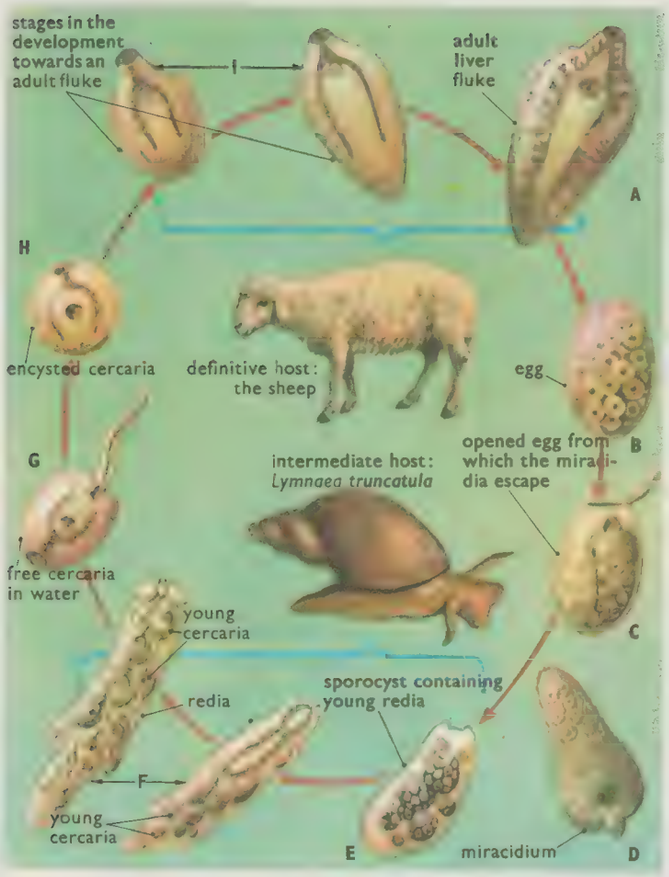
Trichinella spiralis *encysted in muscle fibres*

The domestic animals most often infected by this parasite are pigs, and trichinella reach humans from inadequately cooked pork.

Ascariasis

Ascariasis, or infestation with the large nematode, *Ascaris lumbricoides*, is unusual but not unknown in humans in Britain. The worm is a large one, reaching a foot in length, and its home is in the small bowel (see illustration on the right). A female lays about 1 million eggs each week and these pass out of the host's body with the faeces. Eggs which are eaten by another human ① develop into larvae in the intestine ② and ③, burrow through the wall, and are carried in the blood stream via the liver ④ and heart to the lungs ⑤. They escape into the *alveoli* and are coughed up, only to be swallowed again. This time, each larva develops into a mature worm. Several drugs effectively remove these worms from humans.

A female specimen of the round worm Ascaris lumbricoides



The life cycle of the liver fluke

complicated life cycle with two intermediate hosts: a copepod (a type of small crustacean) and a fish. Humans become infected by eating raw or partly cooked fish meat. This infectation is quite common in parts of Scandinavia.

The liver flukes

Many different species of liver fluke are known, and there are species which infest fish and almost all of the larger animals. Humans are sometimes infected with the large leaf-shaped fluke, *Fasciola hepatica*, which is normally a parasite of sheep.

The illustration on the left shows the cycle of the liver fluke. The fluke (A) lays her eggs (B) in the liver. They pass down the sheep's bile duct into the intestine and are discharged with the faeces. The eggs ripen (C) to form *miracidia* (D) which infect certain species of water snail. Within the snail there develops a *sporocyst* (E) from which a *redia* develops which itself gives rise to a second *redia* (F). From this second redia there emerge free-swimming *cercaria* (G) which find their way on to grass at the water's edge. Here they turn into cysts (H) until eaten by sheep. When a cyst is digested the young fluke emerges. It burrows through the wall of the sheep's intestine until it finds its way to the liver, where the cycle begins all over again (I).

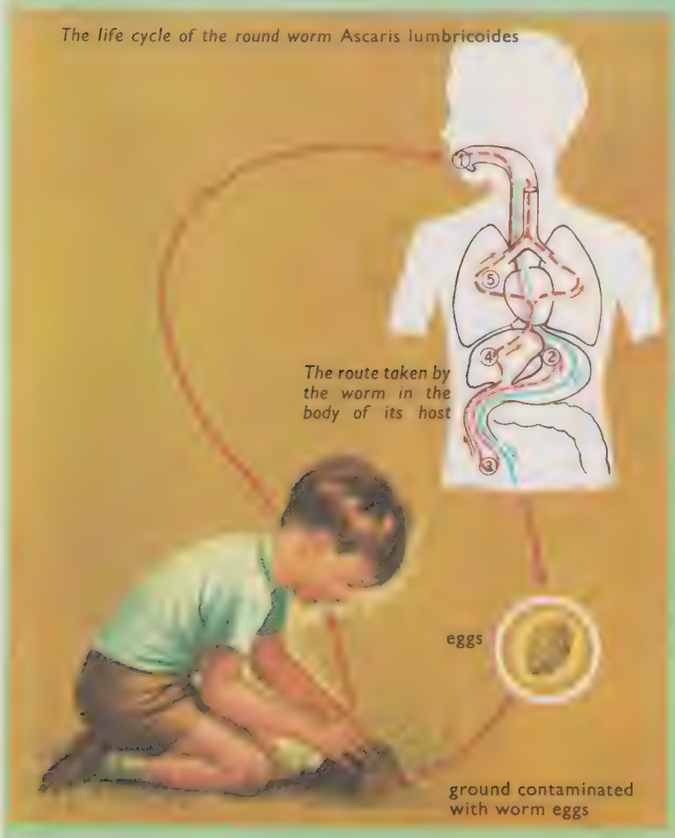
The route by which liver flukes occasionally manage to infect humans is not known with certainty, though it is thought that the infective cyst may lodge on the leaves of watercress.

Three stages in the life cycle of the pork tapeworm

Scolex and first proglottides emerge from cysticercus

BILHARZIASIS

This exceedingly unpleasant tropical illness, which is said to afflict 100 million people, is caused by three species of blood fluke. The intermediate host is a water snail, and in the human hosts the worms congregate in the blood vessels of the pelvis. It occurs in Africa (especially in Egypt), South America, and the Far East.


The life cycle of the round worm Ascaris lumbricoides
The route taken by the worm in the body of its host
eggs
ground contaminated with worm eggs

Threadworms

The threadworm, *Enterobius vermicularis*, is a very common nematode, and almost all children in Britain suffer from at least one infestation before or during their schooldays. The worm, which is only about a quarter of an inch long, lives in the large intestine and its eggs escape from the anus and contaminate the skin around it. This causes itching, and if the victim scratches himself to relieve it the eggs will find their way on to his fingers, from which they easily reach food. From here they travel to another host, and often reinfect their original host too.

The threadworm is susceptible to the action of several drugs including gentian violet, and most infestations can be rapidly got rid of by taking these and by paying strict attention to hygiene.

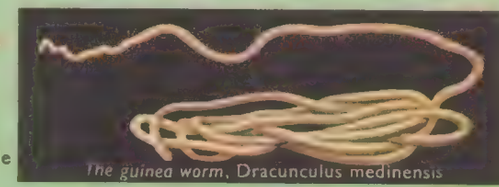
Hookworms

Two species of hookworm are known. They are about one-third of an inch long, and cause widespread illness in tropical countries. They cause severe anaemia.

The guinea worm

The guinea worm, which may grow to 1 yard long, lives under human skin and lays her eggs through a small ulcer. The larvae infect water fleas which are accidentally ingested by the new host.

A hookworm, Ancylostoma duodenale



The guinea worm, Dracunculus medinensis

HISTORY OF SWEDEN

TODAY the Scandinavian states are not among the most powerful countries of Europe. This was not always so. In the early Middle Ages Denmark was extremely strong with an empire that stretched over much of northern Europe (see page 2811). In the 16th and 17th centuries Sweden was the strongest power in the north, and for a brief but glorious period intervened decisively in the main stream of European history.

In the area which is now Sweden lived two main tribal groups – the Swedes and the Goths. The first mention of them is found in the writings of the Roman historian Tacitus (A D 55–120). By 1000 the Swedes had come to dominate the Goths. But Sweden was by no means united. The Swedish king ruled over a loose and semi-independent confederation of provinces. Yet the activities of the Swedes in this early period went far beyond Sweden – they traded with the Byzantine Empire and even farther east. Coins from as far afield as Tashkent and Samarkand have been found in Sweden.

It was not until the 11th century that Sweden became Christian, and this was not without a struggle. The Swedish Church did not have a great deal to do with the rest of the Church and remained more or less independent of Rome.

Gustavus Vasa – the founder of Sweden's greatness

Jean Baptiste Bernadotte – the marshal who became king

The city hall in Stockholm, Sweden's capital

Gustavus VI Adolphus, who became King of Sweden in 1950

The Swedish flag

The Vasas

Between the years 1397 and 1523 Sweden came under Danish influence, being ruled from Copenhagen. But in this period resentment of Danish rule grew. In 1520 Gustavus Vasa (1523–1560), a young Swedish nobleman, raised the standard of revolt. He had neither an army nor money. He began by rallying peasants. As he moved from province to province his support grew. By 1523 Stockholm had fallen to him, and in the same year he was proclaimed King. It was under the Vasa dynasty that the great period of Swedish history began.

The height of Sweden's glory came under Gustavus II Adolphus (1611–1632). By this time Sweden had become Protestant, and Gustavus entered on the Protestant side in the great religious conflict which broke out in 1618 – the Thirty Years War. Gustavus was hailed as the saviour of the Protestant cause. His iron soldiery from the north won victory after victory over the forces of the Emperor. However, in 1632 he met his death at the battle of Lützen where his troops were once more victorious.

At the end of the Thirty Years War (1648) Sweden had gained a colossal empire: Finland, Carelia, Ingria, Estonia, Livonia, West Pomerania, and Bremen.

The 17th century was the high-water mark of Swedish fortunes. The other Baltic states like Russia, Brandenburg, Poland, and Denmark were jealous of Sweden's power. It was a conflict with Russia – the largest and most powerful of these states – that was to bring Sweden her greatest defeat.

When Sweden's young monarch Charles XII (1697–1718; see page 2896) began his reign it seemed for a period that he would revive the glories of Gustavus Adolphus. At Narva in 1700 he routed the forces of Peter the Great, Tsar of Russia (see page 2172), but Charles had met his match in this resourceful monarch. At Poltava in 1709 he was completely routed by Peter.

Russia had now gained a position of pre-eminence in the Baltic world which she was never to lose. And there was a new power rising, the Kingdom of Prussia (formerly the Electorate of Brandenburg). Throughout the 18th century – an age of greatness for both Prussia and Russia – Sweden decreased in power and importance.

Bernadotte

At the end of the century the great powers of Europe became locked in conflict with France. Sweden was an ally of Napoleon, and in 1810 one of Napoleon's marshals was elected Crown Prince. This was Jean Baptiste Bernadotte, Prince of Ponte Corvo. Napoleon may at first have been pleased by this – but it was soon clear that the talented and determined Bernadotte had his own views about Sweden. In 1812 Bernadotte made peace with Napoleon's archenemy, Britain, and allied with Russia. In 1813 he led the northern forces at the battle of Leipzig at which Napoleon was defeated. Thanks to Bernadotte's astute manœuvring, in 1815 Sweden gained Norway from Denmark – this union of Norway and Sweden was to last until 1905 when Norway became independent.

In 1818 Bernadotte became King and so founded the dynasty still ruling in Sweden. Although he was a sane and successful ruler, Sweden was never again to play a decisive part in European history. In fact, in contrast to the 16th, 17th, and 18th centuries, when Sweden was seldom out of a conflict, in the 19th and 20th centuries Sweden kept herself aloof. She took no part in the First or Second World Wars.

Today she still maintains her neutrality in not joining the North Atlantic Treaty Organisation – the military alliance of western powers known as N A T O. However, she does have surprisingly strong armed forces – her air force is the fourth largest in the world.

Democracy comes

For a long time the nobles held political power in Sweden. But as in Britain, a more truly representative government evolved in the 19th century through the national parliament (the *Riksdag*). In 1866 the *Riksdag* (which had had a history of over 500 years) was reformed, and the peasants gained a dominant voice in the new Second Chamber. It was not until 1921 that every adult man and woman was given a vote. Soon after this the Social Democratic Party came to power. Their brand of socialism was moderate and successful. Today Sweden enjoys one of the highest standards of living in Europe.

DID YOU KNOW?

1. *The title of Sweden's king is 'King of Sweden, of the Goths and the Wends'.*
2. *There have been five ruling houses of Sweden since 1523: Vasa, Pfalz-Zweibrücken, Hess, Holstein-Gottorp, and Bernadotte.*

INDUSTRIAL REVOLUTION SIMPLIFIED

WHAT was the Industrial Revolution? Historians are not quite sure. They disagree about when it happened, its significance, what caused it, and how long it lasted. But one thing everyone is agreed on: that between about 1750 and 1850 the face of England was entirely altered. She changed from a sparsely populated rural nation into a densely populated industrial one. The Industrial Revolution is usually associated with advances in technology, shifts in population, and increases in output in the years before 1830. It is now clear that such changes in fact accelerated after that date. After all, the railway, which itself resulted in a major industrial revolution, was not really established until the 1830s. But in this article we will look at some of the traditional factors in the Industrial Revolution – at what happened in the years before the advent of the Railway Age.

TECHNICAL ADVANCES AND INCREASED OUTPUT

There were a number of inventions which resulted in improved efficiency, particularly in the cotton industry.

TECHNICAL ADVANCES IN THE COTTON INDUSTRY

Date	Invention	Inventor
1733	Flying Shuttle	John Kay
1764	Spinning Jenny	James Hargreaves
1769	Water Frame	Richard Arkwright
1779	Mule	Samuel Crompton
1785	Power Loom	Edmund Cartwright

The result was that output of manufactured cotton goods soared. It is reflected in the figures for imported raw cotton.

FIGURES FOR RAW COTTON IMPORTED INTO ENGLAND

Date	Imported raw cotton
1764	4 million lb
1833	300 million lb

There were advances in other industries. The Potteries were developed under men like Josiah Wedgwood, and developments took place in the woollen industry along the same lines as the cotton industry, though at a vastly slower rate. There was also progress in the iron and steel industry.

TECHNICAL ADVANCES IN THE IRON INDUSTRY

Date	Invention	Inventor
1709	Smelting iron with coke instead of charcoal	Abraham Darby
1784	'Puddling and Rolling' (to make wrought iron)	Henry Cort
1820	Hot air blast	James Neilson

Figures in iron production soared.

FIGURES FOR IRON PRODUCTION IN ENGLAND

Date	Output of pig iron
1720	25,000 tons
1788	68,000 tons
1839	1,347,000 tons

Increase in output of coal went hand in hand with that of iron.

FIGURES FOR COAL PRODUCTION IN ENGLAND

Date	Output
1789	6 million tons
1815	15 million tons

One of the most important aspects of the Industrial Revolution was the widespread use of steam power. Until the mid-18th century its use was virtually confined to pumping water out of mines. By 1815 it was used for driving machinery in the textile and iron industries, and was also beginning to be applied to transport.

TECHNICAL ADVANCES IN THE APPLICATION OF STEAM POWER

Date	Invention	Inventor
1698	Steam engine	Thomas Savery
1705	Atmospheric steam engine	Thomas Newcomen
1769	Steam engine with separately cooled condenser	James Watt
1781	Steam engine able to be applied to rotary mechanism and therefore to factory machinery	James Watt
1800	Non-condensing engine	Richard Trevithick

TRANSPORT

The Industrial Revolution speeded up the economic life of Britain. To do this effectively it was necessary to improve communications. At the beginning of the 18th century a journey from York to London took seven days. By the end of the Napoleonic Wars journeys of comparable length were taking less than 24 hours.

Roads. Turnpike trusts were set up which took responsibility for maintaining and developing given stretches of road. They were allowed to charge a toll for the use of these roads. Between 1760 and 1774, 452 Turnpike Acts were passed in Parliament. Road construction was improved by such men as Metcalfe, Telford, and Macadam.

Canals. The most spectacular improvements in transport before the Railway Age were the construction of canals. The first Industrial Revolution canal, built by James Brindley between Worsley and Manchester, was completed in 1761. It was a fantastic success, and within a few years England was linked by a network of canals of over 3,000 miles. The heyday of the 'canal mania' was in the 1790s.

POPULATION

The Industrial Revolution went hand in hand with an increase in population. No one knows quite why, or whether this was a cause or an effect of the revolution.

Date	Population of England
1750	about 6½ million
1801	about 9 million
1821	about 12 million

SUMMARY

As textile factories and iron- and steel-works sprang up, so the rural landscape of parts of England like the Black Country, Lancashire, and South Wales was eaten into. At the same time much of the rest of England was being changed by the enclosure of common land in the farming improvements associated with the Agricultural Revolution (see page 1903). New towns, particularly those in the north like Leeds, Manchester, and Liverpool, developed at an astonishing rate, growing up around the textile industry. After 1785 the steam engine was applied widely to textile machinery. The result was that work in these places was largely concentrated in factories. And so the factory system grew up, staffed by workers packed together into small, badly constructed 'jerry buildings'.

NICOLAUS COPERNICUS

ABOVE their heads the Sun journeyed across the sky each day, and at night a million stars coursed through the firmament. But motionless beneath their feet was the Earth – firm, reliable, and immense. It is not surprising that the people of the Ancient World believed that the sphere on which they stood was the fixed, immovable centre of the Universe and that all the bodies in the starry heavens circled round it. Even the eminent 2nd-century astronomer Ptolemy (see page 1238) thought that he had proved that the Earth was the centre of the Universe and worked out why this should be.

It is true that a revolutionary genius called Aristachus of Samos had put forward a completely different idea in the 3rd century B C. He had suggested that it was the stars which were fixed, and that their motion was only an *apparent* one due to the rotation of the Earth. But there were few who were prepared to accept so bizarre a concept.

For more than a thousand years scholars held to the idea of a Universe with the Earth at its centre. Not until the Renaissance did men again consider the problem seriously and begin to wonder whether, after all, some other arrangement might not provide a better explanation of their astronomical observations. Among those who gave a great deal of attention to this problem was a thoughtful Polish priest called Nicolaus Copernicus.

A student in Italy

Nicolaus Copernicus was born on 10th February 1473 at Torun in Poland. While still a boy he was adopted by his uncle, a priest who intended that his nephew, too, should devote his life to the Church.

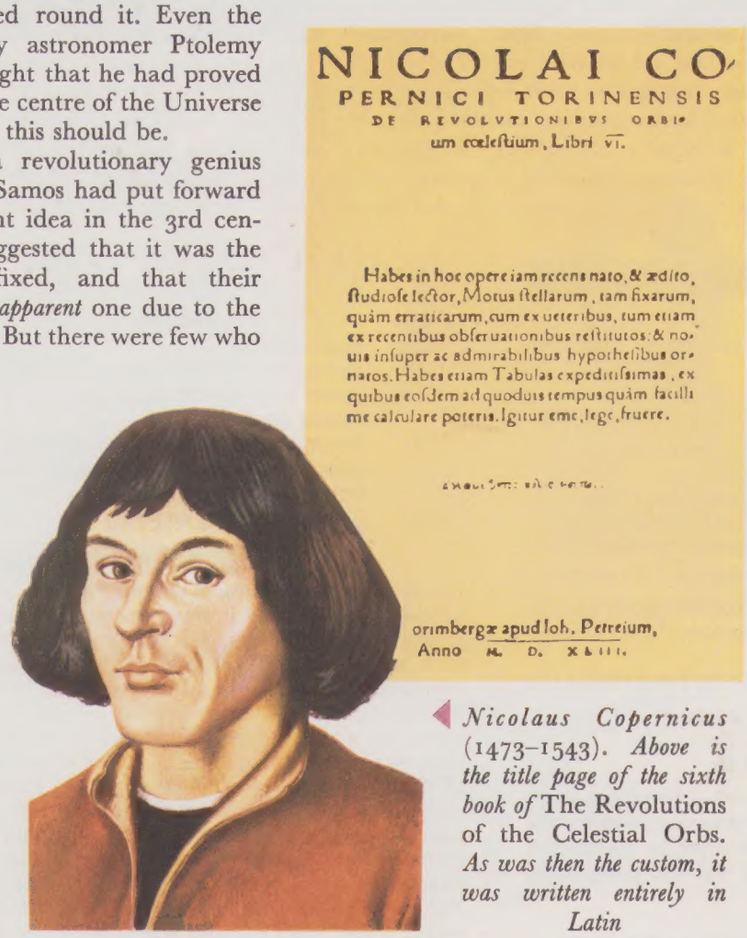
Nicolaus attended the University of Cracow in Poland where he read theology, mathematics, and astronomy. Later he went to Italy where he stayed for about 10 years, studying law at Bologna and medicine at Padua, before being called back to Poland to carry out his duties as a canon and as secretary to his uncle, who was by that time a bishop.

An idea becomes a book

It was probably during his stay in Italy that Copernicus first became seriously interested in the idea that rotation of the Earth might account more neatly for the courses of the Sun and the stars than did Ptolemy's complicated system. When he returned to Poland he continued this line of thought and soon was sufficiently convinced of its correctness to venture into print.

Copernicus's first book, *The Little Commentary*, appeared in 1512; but if he had hoped that his theories would cause a great sensation he must certainly have been disappointed, for they attracted little attention.

Perhaps it was the poor reception given to his first work which caused Copernicus to delay so long before publishing again. Perhaps he felt that it was not for a priest to write on topics which might be at variance with official Church opinion. Whatever the reason, it was not until 30 years later that Copernicus was persuaded to send the results of his life's work to the printer.


NICOLAI CO
PERNICI TORINENSIS
DE REVOLVTIONIBVS ORBI
um cœlestium, Libri VI.

Habes in hoc opere iam recens nato, & ædito, studiose lector, Motus stellarum, tam fixarum, quàm erraticarum, cum ex ueteribus, tum etiam ex recentibus obseruationibus restitutos: & nouis insuper ac admirabilibus hypothesibus ornatos. Habes etiam Tabulas expeditissimas, ex quibus eosdem ad quoduis tempus quàm facilli me calculare poteris. Igitur eme, lege, fruere.

orimbergæ apud Ioh. Petreium,
Anno M. D. XLIII.

Nicolaus Copernicus (1473–1543). *Above is the title page of the sixth book of* The Revolutions of the Celestial Orbs. *As was then the custom, it was written entirely in Latin*

A life's work

In his great work, *Six Books on the Revolutions of the Celestial Orbs*, Copernicus described his conclusions in detail. He stated that the Sun, rather than the Earth, was the centre of the Universe, and the Earth, far from being stationary as most men had thought, journeyed round the Sun once in each year. In addition, the Earth had a spinning motion like a top, so that every place on its surface faced alternately towards and away from the Sun. It was this rotational motion of the Earth, not movement of the Sun and stars, which accounted for the alternation of day and night (see page 2902).

Copernicus attributed similar orbits around the Sun to the other planets known at that time – Mercury, Venus, Mars, Jupiter, and Saturn. For the Moon, however, he had to devise a special motion – an orbit around the Earth – and though this detracted from the neatness of his system it gave the Earth a certain importance, which, at that time, made the Copernican view a little less unacceptable.

The distances of the stars from the Earth are so great that even though Copernicus observed them from two opposite poles of the Earth's orbit around the Sun he could see no demonstrable *parallax* (difference in their apparent positions relative to each other). Copernicus, however, insisted that there *must* be some parallax, and he attributed his failure to observe it to the crudity of 16th-century astronomical instruments – a view which has since been confirmed.

WAS COPERNICUS RIGHT?

Though time has shown that some of the Copernican theory was incorrect – the Sun, for example, is not at the centre of the Universe but is merely a rather ordinary star among millions of others – the contribution which the Polish priest made to astronomy is greater than that of any other man. His work proved an inspiration to such later astronomers as the great Galileo (see page 625), and is indeed the firm foundation on which the whole edifice of astronomical knowledge since the 15th century has been constructed.

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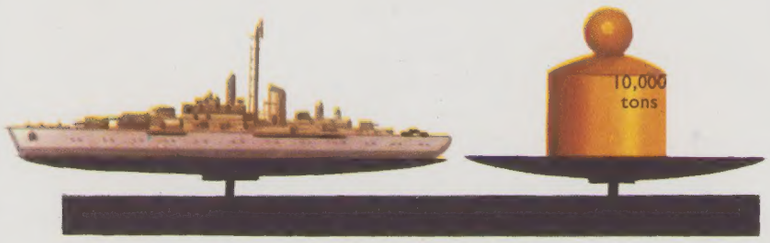
Measuring the size of ships

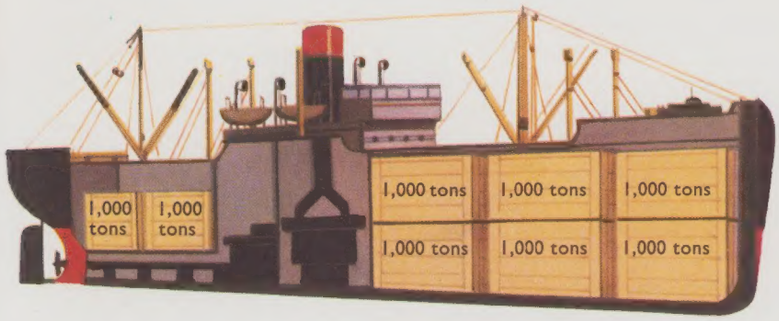
The size of a ship is measured by her *tonnage*. In the case of a warship this is the *displacement tonnage*, or the weight of water in tons which the ship displaces when she floats at her load-



This cruiser weighs 10,000 *tons and she displaces that weight of water. She is therefore said to be of* 10,000 *tons displacement*

line. This weight, of course, is the same as the actual weight of the ship. The displacement tonnage includes the weight of full fuel bunkers, stores, boiler water, ammunition, and crew. A small warship such as a minesweeper has a displacement tonnage of about 430 tons; a large warship such as the aircraft carrier *Ark Royal* has a displacement tonnage of 53,340 tons.

Although displacement tonnage is an absolute measure of the size of a ship, it does not, in the case of a cargo ship, give an exact idea of her carrying capacity. It is quite possible for two merchant ships to have exactly the same displacement, but because one is a fast ship for use on long voyages her engines and bunkers will occupy considerably more space than those of a slower ship on short routes; consequently she will have less



The eight crates, each representing 1,000 *tons, indicate the maximum weight this ship can carry. Her deadweight tonnage is therefore* 8,000 *tons, about* 1,000 *tons of which is fuel, boiler water, stores, and so on*

space available for carrying cargo. To overcome this difficulty and enable purchasers and charterers of ships to know exactly how much cargo-carrying capacity they are paying for, the size of a merchant ship is usually expressed either as the *weight* of cargo that she can carry or as her *volume* of cargo-carrying space.

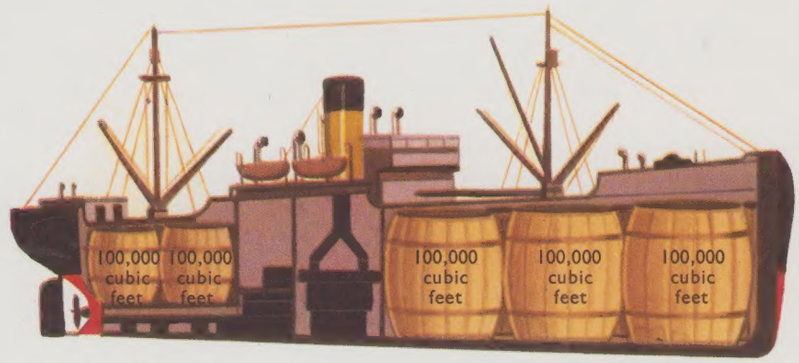
Deadweight tonnage

The weight of cargo that a ship can carry is called her *deadweight tonnage* and is measured in *tons avoirdupois* (the normal English ton of 2,240 pounds). This tonnage must include not only the cargo in the ship's holds but also the weight of passengers, of fuel, and of stores. It also must include any particularly bulky items such as railway engines, timber, and military equipment which may be carried as deck cargo.

If a ship is loaded with a particularly heavy cargo, the deadweight tonnage will weigh her down to the loadline long before her holds are filled. If a light cargo is carried, the ship will ride high even when her holds are full.

Gross and net tonnages

The volume of a ship is measured in *gross* and *net tonnages*. The gross tonnage is greater than the net tonnage because it includes all the enclosed space both beneath the deck and in the superstructure. Each 100 cubic feet of this enclosed space in the ship



The five barrels, each representing 100,000 *cubic feet, indicate the* volume *of all the enclosed spaces within the ship. The gross tonnage is therefore* 5,000 *tons*

is arbitrarily known as 1 ton.

The net tonnage, often called the *register tonnage*, is the volume of all the space in the ship available for the carriage of passengers and cargo. Like the gross tonnage, it is expressed on the basis of 100 cubic feet to the ton. It is easy to see that the net tonnage of a ship is the gross tonnage less the tonnage of those parts of the ship which, from a cargo-carrying viewpoint, are unremunerative. These include the engine room, the fuel bunkers, and the space needed to sail the ship such as the bridge and chart room.

The relationships between the various tonnage measurements are complicated and not constant from one ship to another. A cargo ship of 12,000 tons displacement usually has a hull and machinery weighing about 4,000 tons. The load that she can carry, her deadweight tonnage, is therefore 8,000 tons, about 1,000 tons of which is taken up with fuel, stores, and so on, the remaining 7,000 tons being cargo. The gross tonnage of such a ship would be about 5,000 tons or the equivalent of 500,000 cubic feet of cargo space. The net or register tonnage would be about 3,500 tons.

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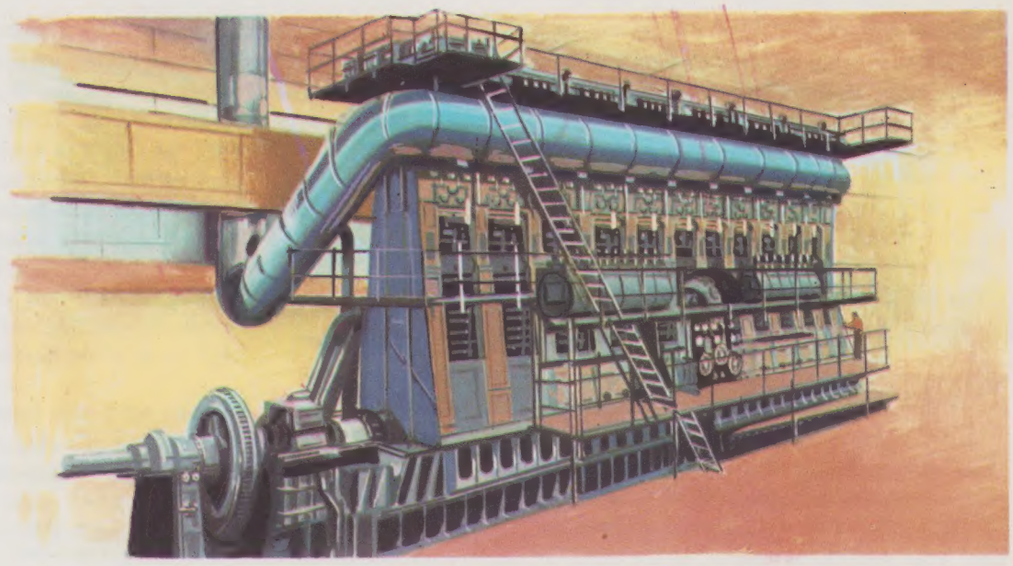
The ship's engines

The steam engine was first adapted for ships at the beginning of the 19th century. Then it was regarded merely as a secondary method of propulsion which could be fitted to sailing ships for use when the winds were unfavourable or there was a flat calm. By the middle years of the century, however, the attitude to the steam engine had changed, and although most steamships still carried sails the engine had become the primary means of propulsion. The sails remained to provide extra speed and economy when there was a favourable wind, and to maintain headway should the engine break down.

All the early steamships were propelled by paddlewheels, but about 1835 the first screw-propelled steamers were built. They proved so successful that screw propellers soon replaced paddles on all ships except those working in shallow water.



A 15,000-*shaft-horsepower diesel engine in the engine room of a cargo ship of* 30,000 *tons gross*

The reciprocating engine

The early steamships had reciprocating engines similar to those still used on steam-powered railway trains. The engines were arranged so that the crankshaft ran transversely and out through the hull on either side where the paddlewheels were attached. A few ferryboats with this arrangement are still in use because their shallow draught makes them suitable for working in estuaries and up to piers.

When the steam engine was required to turn a screw propeller at the stern of the ship a different arrangement had to be made. The engine was placed vertically, with the crankshaft low in the ship and the cylinders above. This arrangement facilitated the introduction of the *compound engine*, in which the steam was made to pass through two, three, or even four cylinders, expanding a little and performing work in each.

The advantages of the reciprocating engine are that once there is steam in the boiler it can be started and stopped easily, and reversing can be carried out rapidly when the ship is being manœuvred in harbour. Furthermore, the reciprocating engine gives as much power for going astern as it does for going ahead.

The turbine

The steam engine is rather cumbersome and heavy, however, in proportion to its output of power. Consequently, when Charles Parsons sailed his little turbine-engined ship *Turbinia* at previously undreamed-of speeds among the warships assembled to celebrate the 60th anniversary of Queen Victoria's accession in 1897, he created an immediate sensation. In the years which followed, the steam turbine supplanted the reciprocating engine as the accepted form of propulsion for all large ships because of its much greater power and simplicity.

Two types of turbine are used for propelling ships – *impulse* and *reaction* turbines. However, neither type will run backwards, so an additional turbine has to be mounted on the same shaft, the other way round, to provide power for going astern. A further complication is that the steam turbine has to run at a speed greater than is necessary to turn the screw. This means that gearing is needed to reduce the turbine revolutions to the correct number of shaft revolutions.

On a few modern ships the turbines are coupled not to the shaft but to electrical generators. The generators provide current for electric motors, and it is these which turn the shaft. The advantages of this very expensive system are that the turbines can be run continuously at their most economic speed and that reversing can be achieved by switching, no extra turbine being needed. This system also enables the engines to be controlled directly from the bridge.

The diesel engine

Diesel engines are used on many ships because their power output is large and relatively little space is needed for fuel bunkers. Furthermore, since no time is taken up with raising steam a diesel can be started in a few minutes.

Diesel engines can be used to turn the screw directly, through gearing, or by electric transmission which, though expensive to install, is by far the best method as it permits the diesel to run continuously in one direction whether the electricity is turning the screw forwards or backwards. This is a great advantage, as reversing a diesel engine is complicated – the engine has to be stopped, the valves adjusted, and the engine restarted in the opposite direction using compressed air stored in *bottles* in the engine room. This is time-consuming and can lead to difficulties when a large ship is being manœuvred in a crowded waterway. British Ministry of Transport regulations require that every motorship shall carry enough compressed air for ten starts.